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FINAL REPORT - Part II

Contract NAS 9-13870

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FINAL REPORT - Part II

Contract NAS 9-13870 (Including Modification 5S)

with

The Methodist Hospital
Houston, Texas

AUTOMATED ELECTROENCEPHALOGRAPHY SYSTEM

AND

ELECTROENCEPHALOGRAPHIC CORRELATES OF SPACE MOTION SICKNESS

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CONTENTS

SECTION 2

28-DAY BED-REST STUDY: SLEEP CHARACTERISTICS

2.1. SUMMARY

Prior to the 28-day bed-rest study, two subjects (J.H., aged 26 years, and R.T., aged 28 years) were chosen for electroencephalographic (EEG), electro-oculographic (EOG), and electromyographic (EMG) monitoring. The individuals were monitored for three consecutive nights in the pre-bed-rest period, during 12 nights of the bed-rest phase, and on the first six nights following termination of bed rest. The data was analyzed, using standardized criteria for the determination of sleep stages. There were several sleep-pattern alterations that were common to both subjects. During the second half of the bed-rest period, sleep latency and stage 3 increased, while total sleep time, stage 2, and REM latency decreased. In addition, during bed rest both subjects showed an increase in the number of REM periods and a slight increase in stage REM amount. No major alterations were seen in the recovery period. Of the alterations found to be associated with bed rest, only one, the increase in stage 3 sleep, was also seen consistently during Skylab. Conversely, none of the post-flight changes seen following Skylab were observed during the post-bed-rest recovery period. It was concluded that in spite of some similarities, the bed-rest study did not appear to provide a situation truly analogous to space flight in terms of sleep characteristics.

2.2. INTRODUCTION

The Skylab findings (Frost et al., 1974, 1975a, b, 1976) suggested that man is able to obtain adequate sleep during prolonged exposure to the weightless environment of space flight. Of the three subjects studied, only one experienced a significant degree of insomnia, and this was a transient phenomenon, confined to the first part of the mission.

However, while adequate sleep was obtained during these excursions, certain alterations in sleep-stage characteristics did occur in flight and in the immediate postflight period. In spite of a considerable amount of individual variation, three findings were common to all subjects: (1) the amount of stage 3 sleep was increased in flight and decreased postflight, compared to preflight baseline studies; (2) stage 4 sleep was consistently decreased in amount postflight; and (3) stage REM sleep was elevated in amount, and its latency decreased, in the late postflight period. In addition, preliminary analysis of the waking EEG characteristics has revealed an increase of the subjects' alpha-rhythm frequency during the in-flight portion of all three missions.

These findings suggest that while the neurophysiological mechanisms responsible for maintenance of the sleep/waking cycle were not severely disrupted by

exposure to the unique environment, they were influenced by it. The nature of this influence cannot be determined from the Skylab data alone, but factors such as altered sensory input and fluid-shift mechanisms must be considered among the most likely possibilities. These factors seem to be worthy of further study, since they may reflect underlying neurophysiological processes which may possibly be involved in the production of the space motion sickness syndrome experienced by several astronauts.

The 28-day bed-rest study provided an opportunity to observe sleeping characteristics of subjects confined to a controlled environment that mimicked some aspects of space flight.

2.3. METHODS

Two subjects (J.H., aged 26 years, and R.T., aged 28 years) were chosen for EEG monitoring. These individuals were monitored concurrently for three consecutive nights in the pre-bed-rest period, during twelve nights of the bed-rest phase (nights 1, 2, 3, 5, 12, 16, 18, 21, 24, 26, 27, and 28), and on the first six nights following termination of bed rest. Each sleep-monitoring session lasted 8 hours.

The subjects slept in the Neurophysiology Sleep Laboratory of The Methodist Hospital during the 21 nights they were monitored. They were instructed to maintain approximately the same schedule, with respect to sleep, on those nights when monitoring was not conducted. In addition, they were asked to refrain from napping during the day.

During each monitoring session, the electroencephalogram (EEG), electrooculogram (EOG), and electromyogram (EMG) were continuously recorded, graphically and on magnetic tape. EEG was derived from six scalp recording electrodes, which provided four channels of data (F_1-C_3, F_2-C_4, C_3-O_1, and C_4-O_2). EOG was recorded from two electrodes, one placed above and the other lateral to the left eye. EMG was detected from a pair of electrodes located in the submental area.

Identical procedures were followed for all recording sessions. The electrodes were attached in the various locations approximately 30 minutes before bedtime (normally, 11:00 p.m.). After calibration and check-out of the recording apparatus, approximately 3 minutes of data were obtained under each of the following conditions: (1) awake, eyes open, relaxed; and (2) awake, eyes closed, relaxed. The lights were then extinguished in the bedroom, the door was closed, and the subjects began the 8-hour sleep period. Upon awakening in the morning, 3-minute samples were again obtained in the eyes-open and eyes-closed conditions, after which the electrodes were removed, and the subjects were permitted to resume their usual activities.

The data was subsequently evaluated, using standardized criteria for the determination of sleep stages, by a combination of human visual and computer techniques. In the statistical evaluation of the results, each subject was considered individually, and the various parameters were grouped into pre-bed-rest, bed-rest, and post-bed-rest categories.

2.4. RESULTS

2.4.1. General

The results of analysis for each night of the study are presented for subject J.H. in Table I, and for subject R.T. in Table II. Average values for the same parameters in the pre-bed-rest (N = 3), bed-rest (N = 12), and post-bed-rest (N = 6) periods for subjects J.H. and R.T. are listed in Tables III and IV, respectively. These tables also indicate the results of between-group comparisons, using a nonparametric statistical test (Mann-Whitney U). Several of the parameters listed in Tables I and II have been plotted versus time to facilitate analysis; thus, Figs. 1-3 pertain to subject J.H., while Figs. 4-6 apply to subject R.T. In all figures, limits (dashed lines), representing plus or minus two standard deviations around the pretest mean, have been projected across the graph. In Tables V and VI, for J.H. and R.T., respectively, the bed-rest period has been divided into first (days 1-12) and second (days 16-28) halves, and average values and between-group comparisons are given for selected parameters.

2.4.2. Sleep and Wakefulness

Neither subject experienced difficulty falling asleep during the pre-bed-rest baseline recordings, and the averages were well below 10 minutes. Sleep latency rose during the bed-rest study (Tables III and IV), with J.H. averaging 26.4 minutes, and R.T. 37.2 minutes. Because of the variability, however, neither was statistically significant. It is clear, though, that this measure exhibited a tendency to increase as the bed-rest phase progressed (Figs. 1 and 4), with highest values seen on days 21 and 24 in both subjects. Thus, J.H. averaged 12.6 minutes during the first half of the bed-rest phase and 35.4 minutes in the second half, while the average values for R.T. were 15.0 minutes and 53.4 minutes, respectively (Tables V and VI). The second-half elevation was statistically significant in the case of R.T. ($\underline{p}<0.01$). Post bed rest, the values for both subjects returned promptly to the pre-bed-rest range, with each averaging 10.2 minutes.

Both subjects slept well during the baseline series, with J.H. averaging 7 hours, 46 minutes total sleep time, and R.T., 7 hours, 40 minutes. Values dropped somewhat during bed rest, with J.H. averaging 7 hours, 26 minutes (20-minute decrease), and R.T. averaging 7 hours, 20 minutes (20-minute decrease). As with sleep latency, the alterations seen occurred primarily in the second half of the bed-rest phase (Tables V and VI), with first-half values almost identical to the baseline average. The second-half values were significantly decreased in both subjects. Post-bed-rest values did not differ significantly from the pre-bed-rest series, although the average value for J.H. was 13.2 minutes below baseline.

By considering the distribution of time spent awake in the various thirds of the night (Tables III and IV), it is clear that the decrease of total sleep time seen in the second half of the study is, in both subjects, due primarily to decreases during the first third. This, in turn, may be accounted for by the sleep-latency alterations described above. This is also evident in Figs. 1 and 4, where the sleep-latency pattern for each subject is mirrored by the total-sleep-time characteristic.

Neither subject exhibited a significant change in the overall number of nocturnal awakenings while at bed rest, although R.T. showed a small decrease in the last third of the night. Post bed rest, subject J.H. showed a slight increase, which was statistically significant. As indicated in Table III, this resulted from an increased number of arousals during the last third of the night.

2.4.3. Sleep-Stage Characteristics

During the pre-bed-rest baseline recording period, the sleep-stage characteristics of both participants were found to be typical of subjects in this age group (20-30 years).

2.4.3.1. Stage 1. There were no stage 1 changes during the study that were common to both subjects. Subject J.H. showed a slight but significant increase in the average percent stage 1 in the post-bed-rest phase (from 14.3% during the baseling studies to 19.6% following bed rest). Subject R.T. had slightly less stage 1 ($p<0.05$) in the first half of the bed-rest study (5.2%), compared to baseline (6.2%).

2.4.3.2. Stage 2. Both subjects had a small but significant ($p<0.05$) drop in percent stage 2 sleep during the second half of the bed-rest phase (J.H., baseline = 51.2%, bed rest, second half = 43.9%; R.T., baseline = 59.4%, bed rest, second half = 51.2%). Average values during the first half were also below baseline but did not achieve statistical significance. Post bed rest, the values for J.H. remained low ($p<0.05$), while those for R.T. returned to the baseline level.

2.4.3.3. Stage 3. The percentage of sleep time occupied by stage 3 tended to increase during the bed-rest period in both subjects, although there was considerable variability from night to night. The highest values were seen in the second half of the study (Tables V and VI). The average value for J.H. rose from 9.7% during the baseline period to 12.6% in the second half ($p<0.05$). A similar but not statistically significant trend was observed in the case of R.T. (baseline = 11.8%; bed rest, second half = 15%). The post-bed-rest values continued to be somewhat elevated but did not differ significantly from the pre-bed-rest values.

2.4.3.4. Stage 4. No significant alterations in stage 4 were seen in either subject, although in the case of R.T. there was a tendency toward somewhat increased values during the second half of the bed-rest study.

2.4.3.5. Stage REM. REM latency is the elapsed time from sleep onset (excluding stage 1) until the first appearance of stage REM. In typical subjects, this measure is usually between 1 and 3 hours. During the baseline period, average values for both subjects fell within this range. A decreased REM latency characterized the second half of the bed-rest period in both subjects (J.H., baseline = 1.0 hours, bed rest, second half = 0.62 hours; R.T., baseline = 1.86 hours, bed rest, second half = 0.85 hours; $p<0.05$). Clearly abnormal values were seen for J.H. on days 16, 21, and 24, when the measure was less than 8 minutes. True sleep-onset stage REM occurred on day 16 (latency = 0), when the subject entered a short stage REM period directly from the drowsy stage, without an intermediate period of stage 2 sleep.

The number of discrete REM periods tended to increase slightly during bed rest for both subjects, but this finding was not statistically significant. A significant increase was, however, observed post bed rest in one subject (J.H., baseline average = 16.7 periods, post-bed-rest average = 24.2 periods).

The percentage of total sleep time spent in stage REM tended to increase slightly during bed rest, but the change was significant only in the case of subject J.H. during the first half of the bed-rest period (baseline = 21.6%; bed rest, first half = 25.7%). Post bed rest, the percent REM values were not significantly different from those seen pre bed rest, although relatively high values were seen on days 4 and 5 for subject J.H. In addition, both subjects exhibited a significant increase in the amount of stage REM that occurred during the final third of the night in the post-bed-rest period, although total REM time remained relatively unchanged.

2.5. DISCUSSION

Most of the sleep-pattern alterations that were common to both subjects were associated with the second half of the 28-day bed-rest period: (1) sleep latency increased, (2) total sleep time decreased, (3) stage 2 decreased, (4) stage 3 increased, and (5) REM latency decreased. Throughout the bed-rest period, both subjects showed some increase in the number of discrete REM periods per night and a slight increase in stage REM amount. In the post-bed-rest phase, there was a relative increase in stage REM during the last third of the night but no overall change in other REM characteristics.

In spite of a reduction in total sleep time in the latter portion of the bed-rest study, neither subject showed objective evidence of sleep deprivation. On no occasion were less than 6½ hours of sleep per night obtained. As pointed out above, the total-sleep-time reduction resulted largely from an increase in sleep latency on certain nights. It is noteworthy that on nights 21 and 24, those associated with the longest sleep-latency measurements, the two subjects were noted to engage in conversation with each other during most of the latency period and thus, to some extent, were voluntarily remaining awake.

These findings differ in several respects from those obtained during Skylab. Sleep latency was significantly altered only during the 84-day Skylab mission, and, in this case, the increase seen was confined to the first half of the flight, rather than to the last half, as observed during the bed-rest study. While a significant reduction in sleep time occurred during the 28-day Skylab flight, it was attributable to a voluntary reduction in total time spent in bed and was not accompanied by an increased sleep latency. The findings are similar in that in neither case did the imposed environment appear to prevent the subjects from obtaining sleep of adequate duration.

The decrease in stage 2 and increase in stage 3 sleep during bed rest are findings that were also seen in two earlier bed-rest studies reported by Ryback

and his co-workers (Ryback and Lewis, 1971; Ryback et al., 1971a, b). In these studies, the increase was seen in both stages 3 and 4, especially in subjects who were not permitted to exercise. Somewhat analogous findings were seen during Skylab, where an in-flight increase in stage 3 was observed during each flight; however, stage 2 was not consistently reduced. While a consistent postflight decrease in stage 4 was seen during Skylab, no such drop was evident in the post-bed-rest period.

The shortening of REM latency, observed during the second half of the bed-rest study, was an unexpected finding, and, in the case of subject J.H., several of the individual values were well below the range typical of normal subjects. In the absence of drug administration or prior REM deprivation, sleep-onset stage REM, such as occurred on night 16 for J.H., or very brief latencies (less than 8 minutes), as on nights 21 and 24, are considered to be abnormal findings. Patients afflicted with narcolepsy often exhibit this pattern in association with the onset of nocturnal sleep or during daytime sleep attacks. Other findings, such as an increased number of REM periods and a slight increase of REM time, seen in both subjects, did not deviate from the normal range.

The REM alterations seen during bed rest were not found during the Skylab studies. In fact, there was a slight tendency for REM to decrease near the end of each Skylab mission, rather than to increase as it did during the final portions of the bed-rest period. Consistent alterations in REM latency and number of REM periods were similarly absent during Skylab. On the other hand, while the most remarkable Skylab findings were the increase in REM time and decrease in REM latency seen in the late postflight period (beyond day R + 3), following bed rest the REM characteristics were essentially the same as those seen pre bed rest. The single exception, common to both subjects, was a redistribution of REM time, with a relative increase in the last third of the night. One bed-rest subject showed a small increase of REM time after day 3, similar to that seen in all three Skylab astronauts. It should be noted that the late postflight Skylab changes in REM characteristics are very similar to the changes seen in the second half of the bed-rest period. While the reasons for the Skylab alterations were not clear, it was postulated that the marked alteration in sensory input, particularly with respect to the visual, vestibular, and proprioceptive systems, might underlie the changes. This hypothesis was based upon evidence which links sleep, and in particular the REM stage, to the neurophysiological mechanisms of memory transformation. Such an explanation does not appear to apply to the bed-rest situation, since the changes were not apparent immediately after the transition to the new environment but appeared only after approximately 2 weeks - a length of time expected to permit relatively complete adaptation. It is, of course, possible that the effects of bed rest may not follow a time course analogous to Skylab and that a similar mechanism could conceivably be in effect.

A summary, comparing the Skylab results with those obtained during the 28-day bed-rest study as well as with those recorded during the Skylab Medical Experiments Altitude Test (SMEAT) (Frost and Salamy, 1973), is provided in Table VII. In preparing this table, sleep characteristics were considered to have been altered whenever a clear-cut difference, compared to baseline, occurred under the imposed test condition. Thus, in some instances, values which did not achieve statistical significance were included.

The incidence of altered sleep characteristics is expressed as a percentage of each group's total membership; for example, in the Skylab column, a value of 33% indicates that one crewman showed this change, while a value of 100% indicates that all three did. In the bed-rest and SMEAT columns, 50% indicates one subject, and 100%, two. In order to quantify the similarity or dissimilarity among the three test conditions, correlations are expressed as percentage values; thus, a correlation of 100% indicates that all members of the specified groups being compared showed the particular alteration.

Consideration of Table VII indicates that during exposure to the three test environments, the most consistently altered characteristic among the three groups was stage 3 sleep, which tended to increase. This was true in all three Skylab astronauts, in both bed-rest subjects, and in one of the two SMEAT crewmen, providing an overall correlation factor (cf) of 50%. Relatively high values (cf = 34%) were seen for total-sleep-time and stage 1 values, both of which tended to decrease in some members of all three groups. An increase of sleep latency and increased amounts of stage 4 were also observed in at least one member of each group. In the post-exposure period, only one alteration (an increase of stage REM after day R + 3) was common to all three environments, with a correlation value of 50%.

Table VII also permits a differential analysis to be made of the efficacy of the SMEAT and bed-rest projects as simulations, with respect to sleep alterations, of actual space flight. As noted previously, only one in-flight alteration (increased stage 3) was common to all three Skylab astronauts. This finding correlated best with the bed-rest project (cf = 100%) but was seen in one SMEAT participant (cf = 50%). Two out of three Skylab subjects had a decreased overall amount of sleep in flight. Again, the bed-rest results (cf = 67%) agreed with the Skylab findings more closely than did those of SMEAT (cf = 34%). With respect to the stage 1 decrease noted in two Skylab crew members, the best correlation was with the SMEAT test (cf = 67%). Thus, the bed-rest study appears to have been somewhat more similar to Skylab in terms of in-flight characteristics. Postflight, four alterations were common to all three astronauts: the increase in stage REM after day R + 3 was also seen in both SMEAT subjects (cf = 100%) and in one bed-rest subject (cf = 50%); the increase in stage 3 and the increase in stage 4 were also observed in one SMEAT participant (cf = 50% for both measures) but in none of the bed-rest subjects (cf = 0 on both comparisons); the decrease in REM latency seen after day R + 3 during Skylab was not seen during bed rest or SMEAT (cf = 0 in both cases). Thus, with respect to postflight findings, SMEAT clearly provided the closest approximation to Skylab.

In spite of some similarities, the bed-rest study did not appear to provide a situation truly analogous to space flight, in terms of sleep characteristics. Alterations in stages 3 and 4 have been reported previously (Ryback and Lewis, 1971; Ryback et al., 1971a, b) in association with bed rest and have been tentatively ascribed to changes in muscular-system status. In particular, subjects undergoing bed rest with no exercise showed the greatest changes. To some extent, we might postulate that this is borne out by the Skylab findings, which also reflected an increase of slow-wave sleep (primarily stage 3). Although the Skylab crew exercised regularly, perhaps some muscle groups were under-utilized. Yet,

we saw a similar change in one of the SMEAT crew members, who almost certainly was not significantly under-exercised and furthermore was living under 1 g environmental conditions. Thus, the increase in stage 3 may well result from some other factor common to all three test situations - perhaps confinement or stress.

The findings with respect to stage REM argue most strongly against the bed-rest situation as an analogue of in-flight sleeping conditions. REM latency decreased to abnormal levels in one subject, and a similar tendency was noted in the other. In addition, REM amount tended to increase near the end of the bed-rest period, while in Skylab it tended to decrease. Changes in REM were not significant in the earlier bed-rest studies, but this may have been due to the long sampling intervals used in the previous studies.

During Skylab, we also observed certain alterations in the basic EEG characteristics - most notably an in-flight increase in the alpha-rhythm frequency. We are now making a similar analysis of the bed-rest data, but the results are not yet available for comparison. Pending these results, which may alter our opinion, the conclusion appears to be that bed rest, while associated with alterations in sleep characteristics, for the most part does not influence this physiological process in a manner comparable to the weightless environment of space flight. Out of eight alterations associated with bed rest, only one, an increase in stage 3 sleep, was also seen consistently during Skylab. Conversely, none of the four Skylab changes seen postflight were observed consistently in the post-bed-rest phase.

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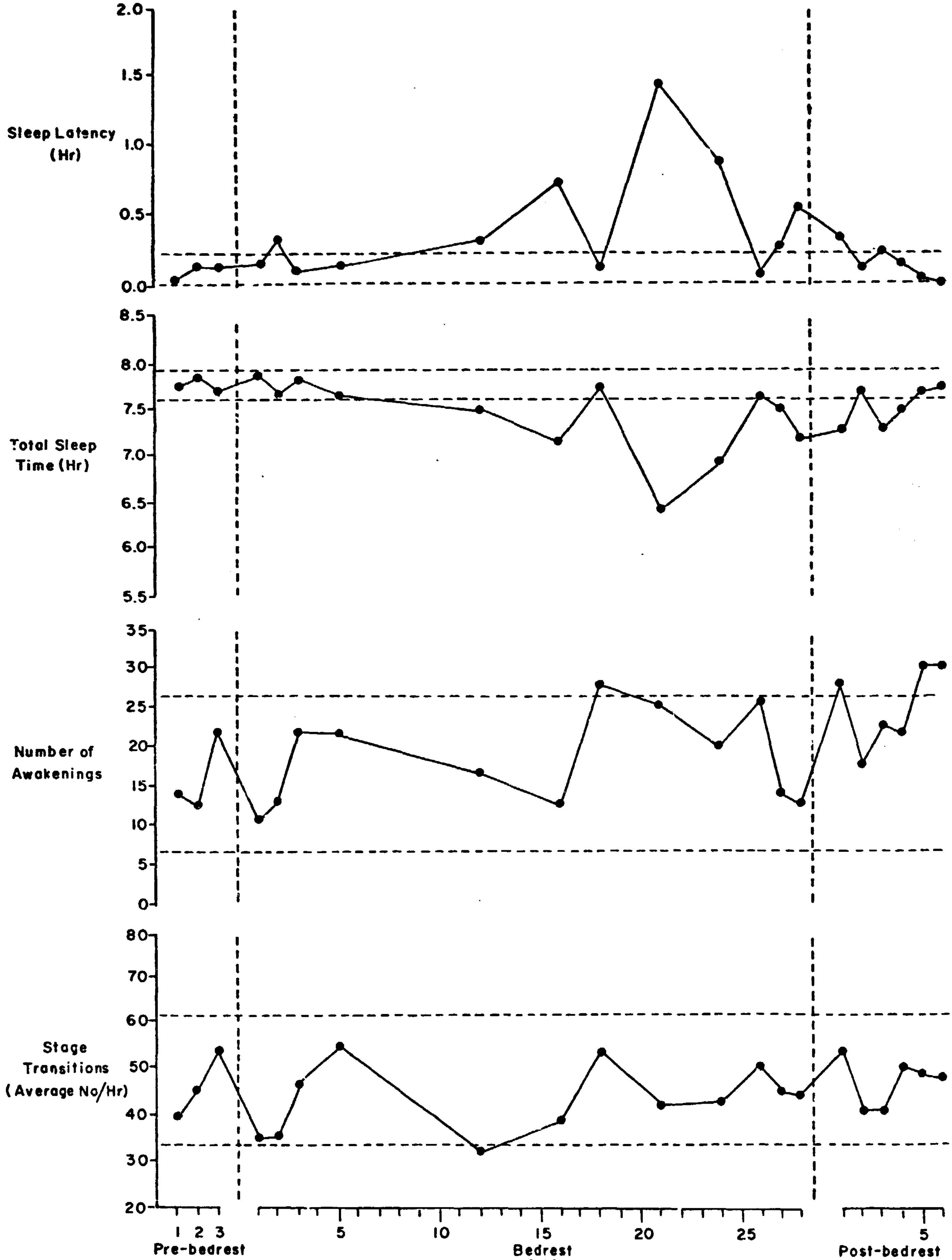
FIGURES AND TABLES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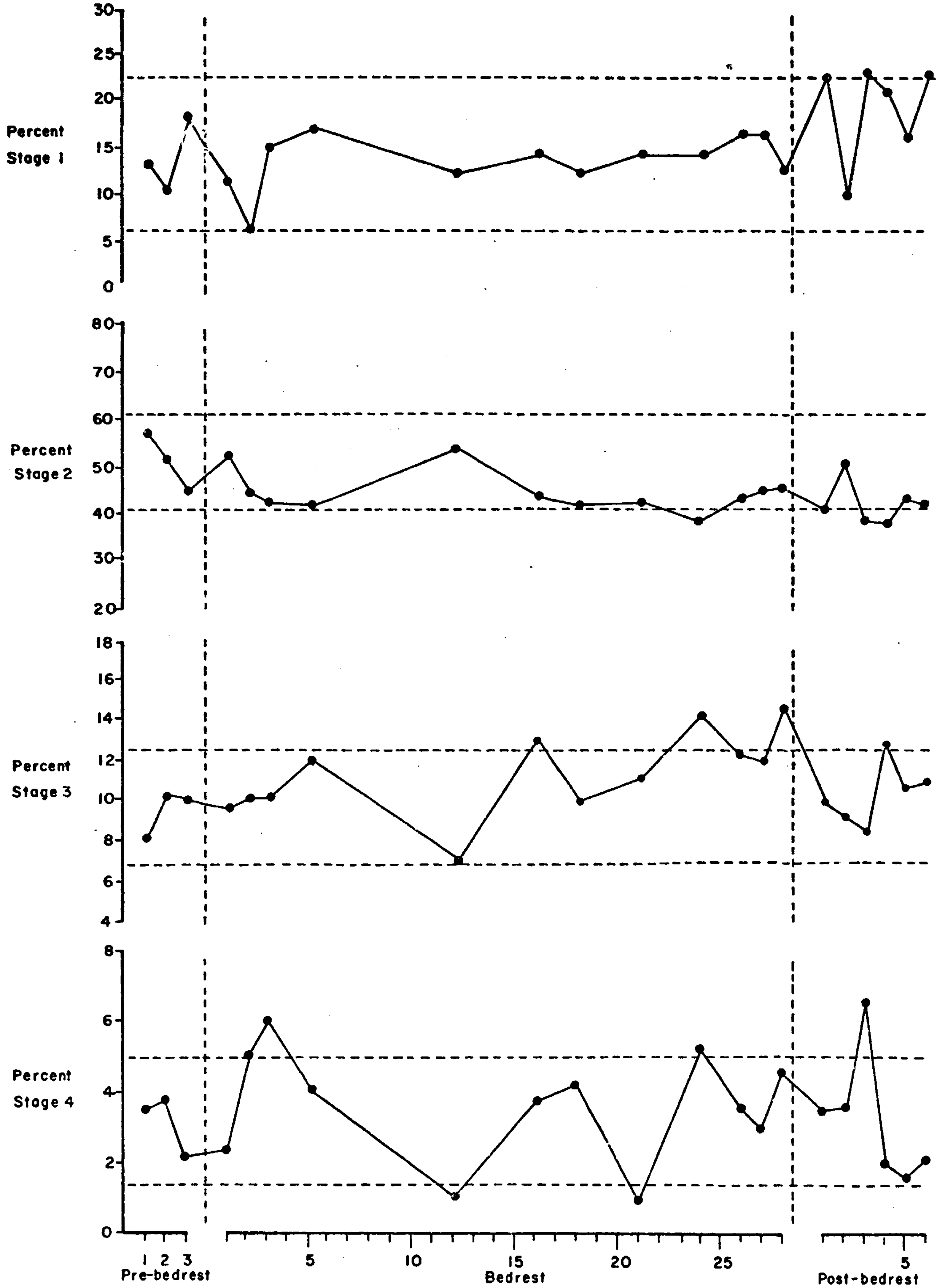
0.5
0.0
Total Sleep Time (Hr)
8.5
8.0
7.5
7.0
6.5
6.0
5.5
Number of Awakenings
35
30
25
20
15
10
5
0
Stage Transitions (Average No/Hr)
80
70
60
50
40
30
20
1 2 3
Pre-bedrest
5
10
15
20
25
Bedrest
5
Post-bedrest

J.H.

Fig. I



Percent Stage 1
Percent Stage 2
Percent Stage 3
Percent Stage 4
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25
20
15
10
5
0
80
70
60
50
40
30
20
18
16
14
12
10
8
6
4
8
6
4
2
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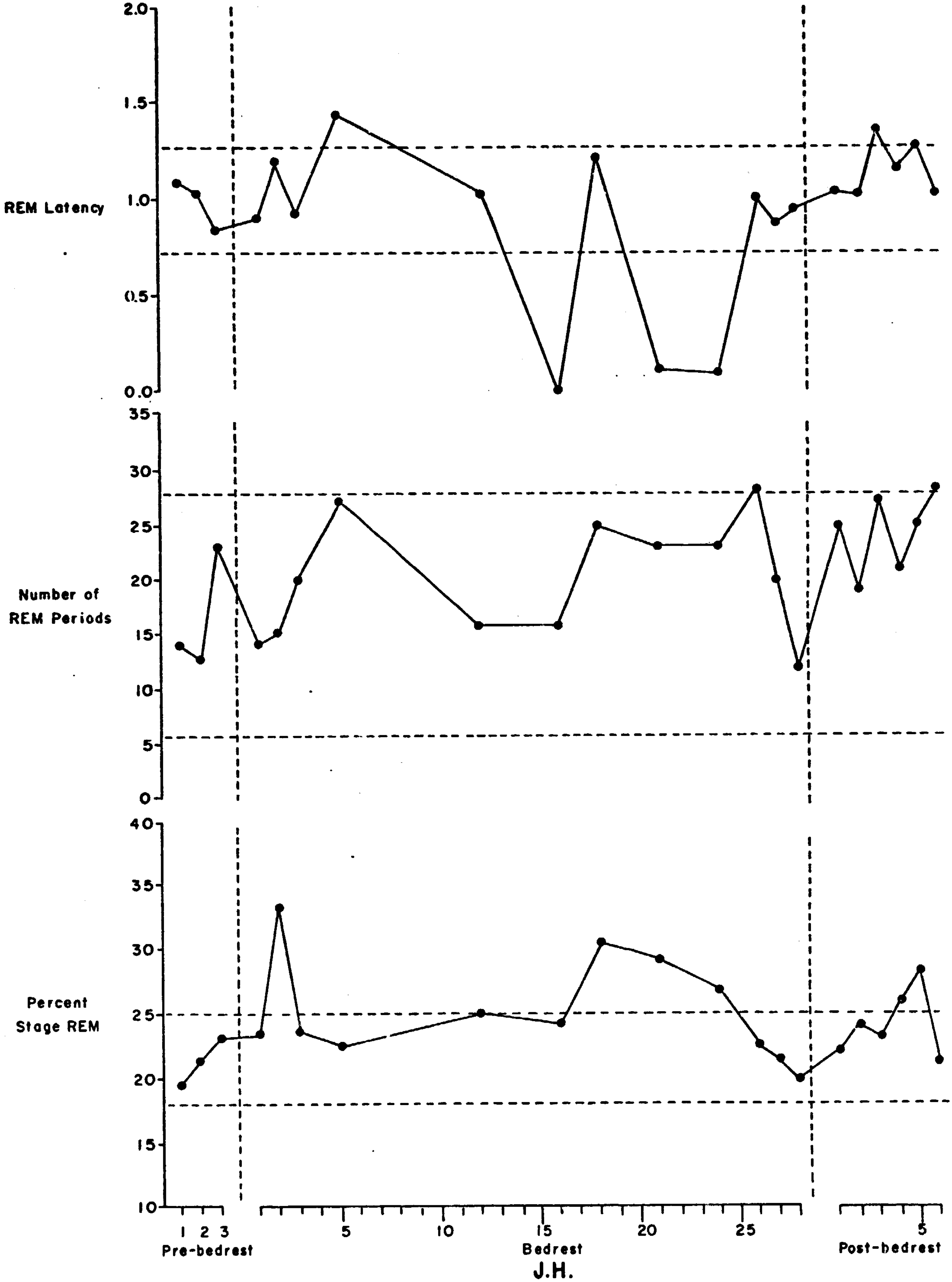
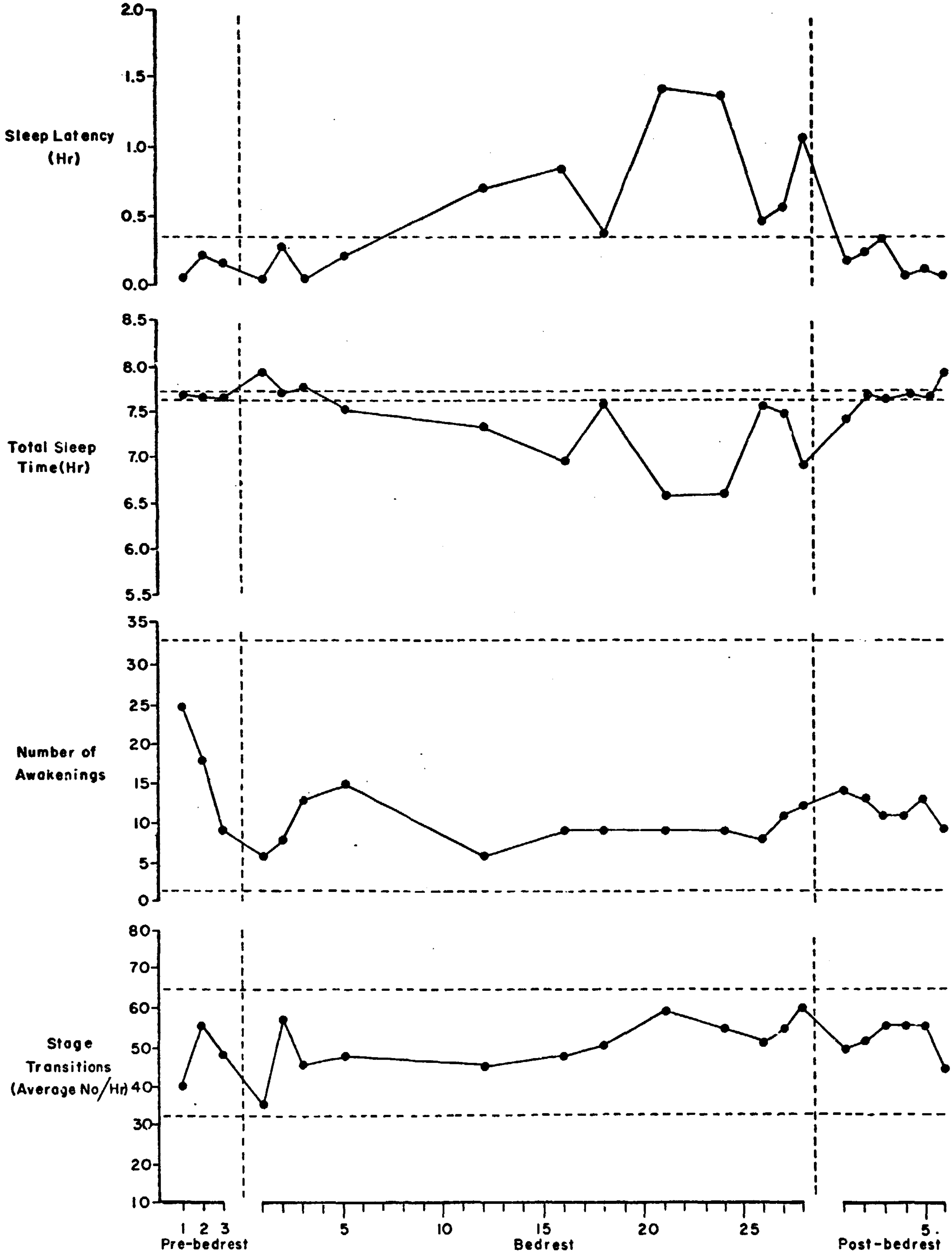
1 2 3
Pre-bedrest
5
10
15
20
25
Bedrest
5
Post-bedrest

J. H.
Fig. 2



REM Latency
Number of
REM Periods
Percent
Stage REM
2.0
1.5
1.0
0.5
0.0
35
30
25
20
15
10
5
0
40
35
30
25
20
15
10
1 2 3
Pre-bedrest
5
10
15
20
25
Bedrest
5
Post-bedrest
J.H.

Fig. 3



Sleep Latency (Hr)
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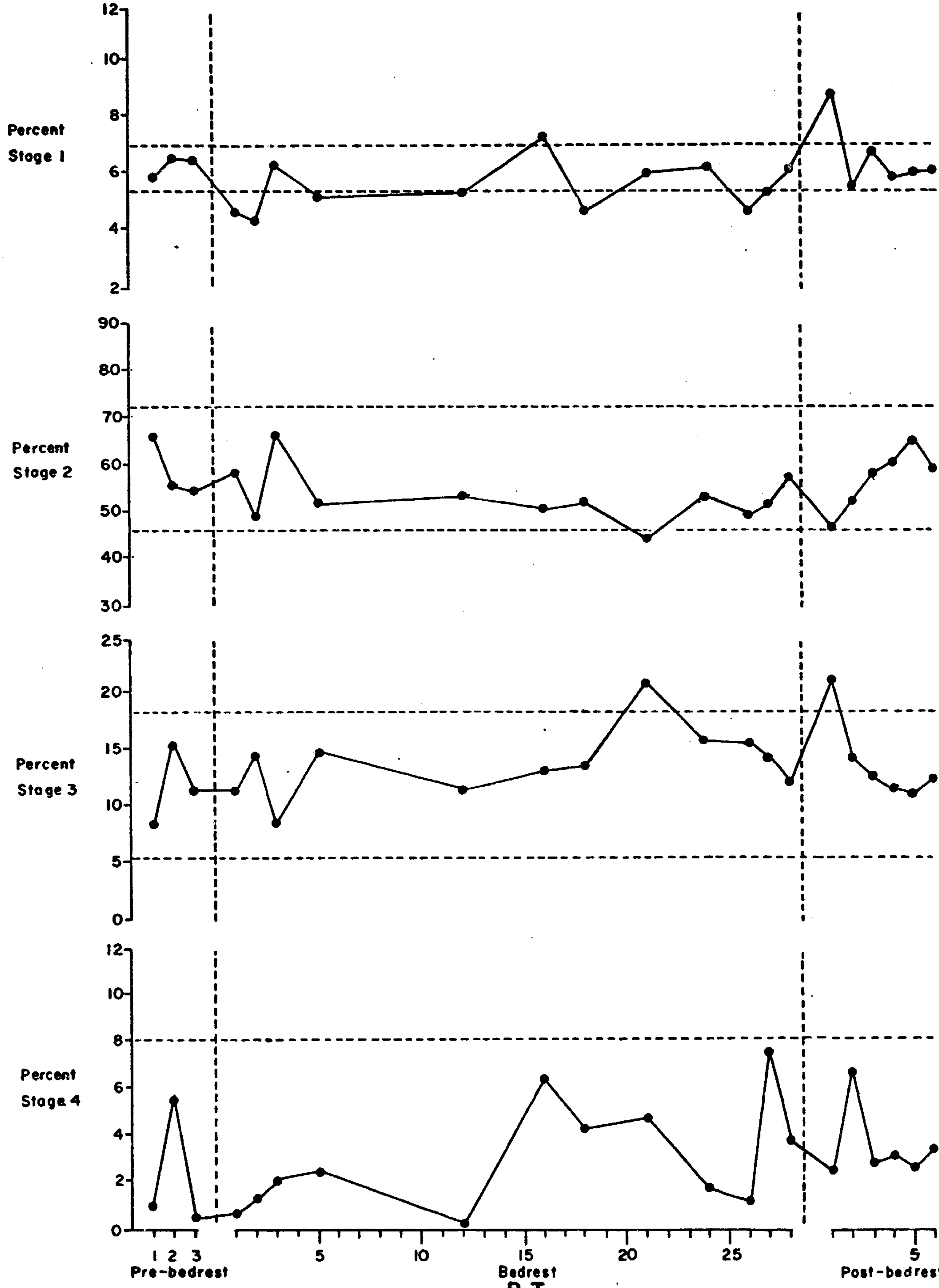
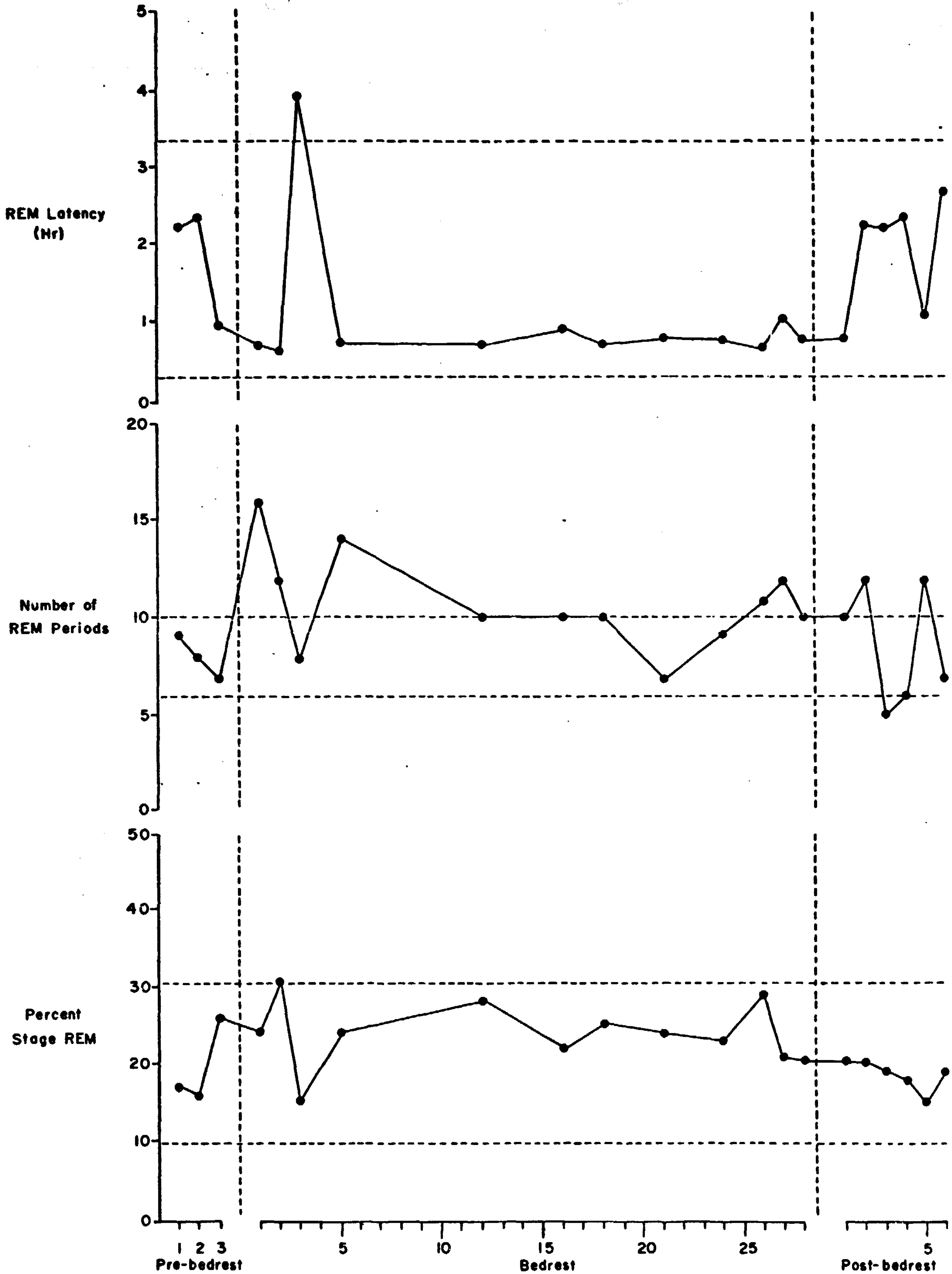
1.5
1.0
0.5
0.0
Total Sleep Time(Hr)
8.5
8.0
7.5
7.0
6.5
6.0
5.5
Number of Awakenings
35
30
25
20
15
10
5
0
Stage Transitions (Average No/Hr)
80
70
60
50
40
30
20
10
1 2 3
Pre-bedrest
5
10
15
20
25
Bedrest
5.
Post-bedrest

R.T.
Fig. 4



Percent Stage 1
Percent Stage 2
Percent Stage 3
Percent Stage 4
12
10
8
6
4
2
90
80
70
60
50
40
30
25
20
15
10
5
0
1 2 3
Pre-bedrest
5
10
15
20
25
Bedrest
5
Post-bedrest
R.T.

Fig. 5


REM Latency (Hr)
Number of REM Periods
Percent Stage REM
0
1
2
3
4
5
10
15
20
25
30
40
50
1 2 3
Pre-bedrest
Bedrest
Post-bedrest

R. T.
Fig. 6

Table I.

NASA BEDREST STUDY

	PRE-TEST			TEST									
TEST DAYS	1	2	3	1	2	3	5	12	16	18	21	24	26
Total Time in Bed	8.04	8.05	8.03	8.04	8.04	8.06	8.02	8.04	8.04	8.06	8.02	8.02	8.07
Total Sleep Time	7.75	7.85	7.70	7.88	7.68	7.84	7.67	7.51	7.19	7.74	6.41	6.95	7.65
Total Sleep Percent	96.4	97.5	95.9	97.9	95.6	97.3	95.6	93.4	89.5	96.0	79.9	86.6	94.8
Total Awake Time	0.29	0.20	0.33	0.17	0.35	0.22	0.35	0.53	0.85	0.33	1.62	1.07	0.42
1 st 3rd	0.04	0.11	0.05	0.08	0.24	0.06	0.09	0.15	0.61	0.08	1.32	0.81	0.05
2 nd 3rd	0.09	0.03	0.09	0.01	0.04	0.08	0.08	0.18	0.06	0.05	0.09	0.04	0.15
3 rd 3rd	0.16	0.07	0.19	0.08	0.07	0.09	0.18	0.20	0.18	0.20	0.21	0.22	0.23
Sleep Latency	0.06	0.16	0.16	0.17	0.31	0.11	0.16	0.31	0.73	0.13	1.44	0.89	0.10
REM Latency	1.12	1.04	0.84	0.91	1.22	0.94	1.44	1.03	0.00	1.24	0.13	0.10	1.00
Number of Awakenings	14	13	22	11	13	22	22	17	13	28	25	20	26
1 st 3rd	2	0	3	2	1	1	2	2	1	3	2	0	1
2 nd 3rd	7	5	7	2	4	10	8	7	7	6	8	5	8
3 rd 3rd	5	8	12	7	8	11	12	8	5	19	15	15	17
Number of REM Periods	14	13	23	14	15	20	27	16	16	25	23	23	28
1 st 3rd	1	3	3	3	3	2	4	1	4	5	1	4	3
2 nd 3rd	6	4	7	4	6	7	9	7	5	7	12	5	11
3 rd 3rd	7	6	13	7	6	11	14	8	7	13	10	14	14
Stage 1 Time	1.02	0.86	1.46	0.91	0.47	1.20	1.36	0.94	1.07	0.97	0.94	1.02	1.30
% Stage 1	13.2	10.9	18.9	11.5	6.2	15.3	17.7	12.5	14.9	12.5	14.7	14.7	17.0
Stage REM Time	1.53	1.71	1.78	1.85	2.56	1.88	1.74	1.88	1.74	2.36	1.87	1.88	1.73
1 st 3rd	0.25	0.44	0.34	0.38	0.35	0.37	0.33	0.29	0.32	0.35	0.04	0.38	0.36
2 nd 3rd	0.38	0.66	0.67	0.80	0.95	0.59	0.42	0.71	0.77	0.79	1.05	0.47	0.48
3 rd 3rd	0.91	0.61	0.78	0.67	1.26	0.92	0.99	0.88	0.65	1.22	0.78	1.03	0.89
% Stage REM	19.8	21.8	23.2	23.5	33.3	23.9	22.8	25.1	24.3	30.6	29.2	27.0	22.7
Stage 2 Time	4.29	4.14	3.50	4.17	3.46	3.44	3.31	4.05	3.17	3.30	2.78	2.70	3.39
% Stage 2	55.4	52.8	45.5	53.0	45.1	43.8	43.1	53.9	44.0	42.6	43.3	38.8	44.4
Stage 3 Time	0.63	0.84	0.79	0.76	0.79	0.85	0.94	0.55	0.95	0.78	0.76	0.99	0.94
% Stage 3	8.1	10.8	10.3	9.7	10.3	10.8	12.3	7.3	13.2	10.1	11.8	14.3	12.4
Stage 4 Time	0.28	0.30	0.17	0.19	0.40	0.48	0.32	0.09	0.26	0.33	0.06	0.37	0.28
% Stage 4	3.6	3.8	2.2	2.4	5.2	6.2	4.2	1.3	3.7	4.2	0.9	5.3	3.7
Transitions/Hr.	40	47	54	35	36	48	55	32	39	54	43	44	51

J. H.

FOLDOUT FRAME 1

Table I.

NASA BEDREST STUDY

TEST											POST-TEST					
2	3	5	12	16	18	21	24	26	27	28	1	2	3	4	5	6
8.04	8.06	8.02	8.04	8.04	8.06	8.02	8.02	8.07	8.07	8.04	8.04	8.03	8.03	8.04	8.03	8.03
7.68	7.84	7.67	7.51	7.19	7.74	6.41	6.95	7.65	7.51	7.16	7.28	7.71	7.33	7.53	7.72	7.74
95.6	97.3	95.6	93.4	89.5	96.0	79.9	86.6	94.8	93.1	89.1	90.5	96.0	91.3	93.7	96.1	96.4
0.35	0.22	0.35	0.53	0.85	0.33	1.62	1.07	0.42	0.56	0.88	0.76	0.32	0.70	0.51	0.31	0.29
0.24	0.06	0.09	0.15	0.61	0.08	1.32	0.81	0.05	0.21	0.53	0.23	0.07	0.18	0.09	0.04	0.03
0.04	0.08	0.08	0.18	0.06	0.05	0.09	0.04	0.15	0.04	0.05	0.18	0.16	0.19	0.15	0.10	0.03
0.07	0.09	0.18	0.20	0.18	0.20	0.21	0.22	0.23	0.31	0.29	0.36	0.09	0.33	0.27	0.17	0.23
0.31	0.11	0.16	0.31	0.73	0.13	1.44	0.89	0.10	0.29	0.58	0.35	0.15	0.26	0.19	0.07	0.02
1.22	0.94	1.44	1.03	0.00	1.24	0.13	0.10	1.00	0.89	0.95	1.05	1.04	1.36	1.19	1.29	1.04
13	22	22	17	13	28	25	20	26	14	13	28	18	23	22	30	30
1	1	2	2	1	3	2	0	1	2	3	1	1	1	2	1	1
4	10	8	7	7	6	8	5	8	4	3	8	8	4	8	9	6
8	11	12	8	5	19	15	15	17	8	7	19	9	18	12	20	23
15	20	27	16	16	25	23	23	28	20	12	25	19	27	21	25	28
3	2	4	1	4	5	1	4	3	4	2	4	5	1	5	2	3
6	7	9	7	5	7	12	5	11	7	2	10	7	6	6	8	5
6	11	14	8	7	13	10	14	14	9	8	11	7	20	10	15	20
0.47	1.20	1.36	0.94	1.07	0.97	0.94	1.02	1.30	1.26	0.95	1.67	0.79	1.70	1.60	1.27	1.79
6.2	15.3	17.7	12.5	14.9	12.5	14.7	14.7	17.0	16.7	13.2	22.9	10.2	23.2	21.3	16.5	23.2
2.56	1.88	1.74	1.88	1.74	2.36	1.87	1.88	1.73	1.62	1.43	1.61	1.87	1.69	1.96	2.19	1.66
0.35	0.37	0.33	0.29	0.32	0.35	0.04	0.38	0.36	0.28	0.29	0.14	0.33	0.28	0.36	0.11	0.44
0.95	0.59	0.42	0.71	0.77	0.79	1.05	0.47	0.48	0.54	0.51	0.65	0.58	0.58	0.35	0.86	0.14
1.26	0.92	0.99	0.88	0.65	1.22	0.78	1.03	0.89	0.80	0.63	0.82	0.96	0.83	1.25	1.23	1.09
33.3	23.9	22.8	25.1	24.3	30.6	29.2	27.0	22.7	21.5	20.0	22.2	24.2	23.1	26.0	28.4	21.5
3.46	3.44	3.31	4.05	3.17	3.30	2.78	2.70	3.39	3.50	3.41	3.01	4.04	2.84	2.86	3.3	3.28
45.1	43.8	43.1	53.9	44.0	42.6	43.3	38.8	44.4	46.6	47.6	41.4	52.4	38.8	38.0	42.8	42.3
0.79	0.85	0.94	0.55	0.95	0.78	0.76	0.99	0.94	0.90	1.04	0.72	0.72	0.61	0.95	0.82	0.85
10.3	10.8	12.3	7.3	13.2	10.1	11.8	14.3	12.4	12.0	14.5	9.9	9.3	8.4	12.7	10.6	11.0
0.40	0.48	0.32	0.09	0.26	0.33	0.06	0.37	0.28	0.24	0.33	0.26	0.29	0.48	0.15	0.13	0.16
5.2	6.2	4.2	1.3	3.7	4.2	0.9	5.3	3.7	3.2	4.7	3.6	3.8	6.6	2.0	1.7	2.1
36	48	55	32	39	54	43	44	51	46	45	54	42	42	51	48	47

J. H.

FOLDOUT FRAME 2

Table II.

NASA BEDREST STUDY

	PRE-TEST			TEST										
TEST DAYS	1	2	3	1	2	3	5	12	16	18	21	24	26	
Total Time in Bed	8.04	8.06	8.05	8.05	8.05	8.09	8.04	8.06	8.04	8.05	8.04	8.04	8.08	8
Total Sleep Time	7.69	7.67	7.66	7.97	7.71	7.78	7.51	7.33	6.96	7.61	6.59	6.60	7.56	7
Total Sleep Percent	95.7	95.2	95.2	99.0	95.8	96.2	93.3	90.9	86.5	94.6	82.0	82.0	93.6	9
Total Awake Time	0.34	0.39	0.39	0.08	0.34	0.31	0.54	0.73	1.08	0.44	1.45	1.45	0.52	0
1 st 3rd	0.09	0.18	0.13	0.03	0.22	0.06	0.18	0.65	0.83	0.34	1.39	1.36	0.44	0
2 nd 3rd	0.14	0.02	0.02	0.01	0.08	0.19	0.28	0.05	0.14	0.03	0.01	0.03	0.01	0
3 rd 3rd	0.11	0.19	0.24	0.04	0.04	0.06	0.08	0.03	0.11	0.07	0.06	0.06	0.07	0.
Sleep Latency	0.06	0.23	0.18	0.04	0.27	0.04	0.20	0.71	0.85	0.38	1.43	1.39	0.49	0.
REM Latency	2.25	2.35	0.97	0.75	0.63	3.96	0.79	0.78	0.90	0.77	0.86	0.83	0.72	1.
Number of Awakenings	25	18	9	6	8	13	15	6	9	9	9	9	8	
1 st 3rd	4	1	0	1	1	4	3	0	0	2	1	0	0	
2 nd 3rd	11	3	2	2	2	6	6	2	2	3	1	3	2	
3 rd 3rd	10	14	7	3	5	3	6	4	7	4	7	6	6	
Number of REM Periods	9	8	7	16	12	8	14	10	10	10	7	9	11	
1 st 3rd	2	1	2	5	7	0	6	2	2	2	1	2	3	
2 nd 3rd	2	4	3	6	2	3	4	4	5	5	1	3	2	
3 rd 3rd	5	3	2	5	3	5	4	4	3	3	5	4	6	
Stage 1 Time	0.44	0.50	0.49	0.36	0.33	0.49	0.39	0.39	0.51	0.36	0.39	0.41	0.36	0.
% Stage 1	5.8	6.5	6.4	4.6	4.3	6.3	5.2	5.4	7.4	4.7	6.0	6.2	4.7	5.
Stage REM Time	1.37	1.27	2.01	1.93	2.39	1.22	1.85	2.09	1.57	1.95	1.58	1.55	2.21	1.
1 st 3rd	0.10	0.10	0.08	0.35	0.42	0.00	0.35	0.19	0.01	0.12	0.13	0.10	0.19	0.
2 nd 3rd	0.52	0.48	1.23	0.92	0.30	0.44	0.27	0.65	0.92	0.67	0.51	0.67	0.80	0.
3 rd 3rd	0.76	0.70	0.70	0.67	1.66	0.79	1.23	1.26	0.63	1.16	0.95	0.78	1.22	1.
% Stage REM	17.8	16.6	26.2	24.3	30.9	15.7	24.6	28.6	22.5	25.7	24.0	23.5	29.2	21
Stage 2 Time	5.14	4.30	4.24	4.68	3.75	5 23	3.98	3.97	3.53	3.94	2.93	3.49	3.72	3.
% Stage 2	66.8	56.1	55.3	58.7	48.6	67.2	52.9	54.2	50.7	51.7	44.5	52.9	49.2	52
Stage 3 Time	0.66	1.17	0.89	0.93	1.14	0.69	1.12	0.86	0.91	1.04	1.36	1.03	1.18	1.
% Stage 3	8.6	15.2	11.7	11.7	14.8	8.8	14.9	11.7	13.1	13.6	20.7	15.7	15.6	14
Stage 4 Time	0.08	0.43	0.04	0.06	0.11	0.16	0.18	0.01	0.44	0.33	0.32	0.12	0.09	0.
% Stage 4	1.1	5.6	0.5	0.8	1.4	2.0	2.3	0.2	6.4	4.3	4.8	1.8	1.3	7.
Transitions/Hr.	40	56	48	36	58	46	48	46	48	51	59	55	52	55

R. T.

FOLDOUT FRAME 1

Table II.

NASA BEDREST STUDY

TEST											POST-TEST					
2	3	5	12	16	18	21	24	26	27	28	1	2	3	4	5	6
8.05	8.09	8.04	8.06	8.04	8.05	8.04	8.04	8.08	8.11	8.06	8.03	8.04	8.05	8.05	8.05	8.04
7.71	7.78	7.51	7.33	6.96	7.61	6.59	6.60	7.56	7.46	6.94	7.39	7.68	7.63	7.73	7.73	7.93
95.8	96.2	93.3	90.9	86.5	94.6	82.0	82.0	93.6	92.0	86.1	92.1	95.5	94.8	95.9	96.0	98.6
0.34	0.31	0.54	0.73	1.08	0.44	1.45	1.45	0.52	0.65	1.12	0.64	0.36	0.42	0.33	0.32	0.12
0.22	0.06	0.18	0.65	0.83	0.34	1.39	1.36	0.44	0.51	1.01	0.14	0.19	0.30	0.04	0.17	0.04
0.08	0.19	0.28	0.05	0.14	0.03	0.01	0.03	0.01	0.06	0.03	0.39	0.06	0.05	0.04	0.02	0.02
0.04	0.06	0.08	0.03	0.11	0.07	0.06	0.06	0.07	0.08	0.09	0.11	0.11	0.08	0.24	0.13	0.06
0.27	0.04	0.20	0.71	0.85	0.38	1.43	1.39	0.49	0.57	1.09	0.17	0.23	0.34	0.08	0.12	0.06
0.63	3.96	0.79	0.78	0.90	0.77	0.86	0.83	0.72	1.04	0.81	0.82	2.26	2.23	2.36	1.12	2.71
8	13	15	6	9	9	9	9	8	11	12	14	13	11	11	13	9
1	4	3	0	0	2	1	0	0	0	1	1	0	0	0	3	2
2	6	6	2	2	3	1	3	2	5	3	3	5	4	3	3	2
5	3	6	4	7	4	7	6	6	6	8	10	8	7	8	7	5
12	8	14	10	10	10	7	9	11	12	10	10	12	5	6	12	7
7	0	6	2	2	2	1	2	3	3	1	2	1	1	1	4	0
2	3	4	4	5	5	1	3	2	3	4	1	4	3	2	3	2
3	5	4	4	3	3	5	4	6	6	5	7	7	1	3	5	5
0.33	0.49	0.39	0.39	0.51	0.36	0.39	0.41	0.36	0.41	0.42	0.65	0.42	0.52	0.45	0.46	0.48
4.3	6.3	5.2	5.4	7.4	4.7	6.0	6.2	4.7	5.4	6.1	8.8	5.5	6.8	5.8	6.0	6.1
2.39	1.22	1.85	2.09	1.57	1.95	1.58	1.55	2.21	1.57	1.42	1.53	1.56	1.46	1.46	1.17	1.53
0.42	0.00	0.35	0.19	0.01	0.12	0.13	0.10	0.19	0.09	0.10	0.35	0.19	0.11	0.15	0.11	0.00
0.30	0.44	0.27	0.65	0.92	0.67	0.51	0.67	0.80	0.48	0.73	.27	0.39	0.63	0.49	0.31	0.52
1.66	0.79	1.23	1.26	0.63	1.16	0.95	0.78	1.22	1.00	0.60	0.91	0.98	0.72	0.81	0.75	1.01
30.9	15.7	24.6	28.6	22.5	25.7	24.0	23.5	29.2	21.0	20.5	20.7	20.4	19.2	18.8	15.1	19.3
3.75	5.23	3.98	3.97	3.53	3.94	2.93	3.49	3.72	3.88	3.99	3.47	4.10	4.46	4.67	5.01	4.64
48.6	67.2	52.9	54.2	50.7	51.7	44.5	52.9	49.2	52.0	57.5	47.0	53.3	58.5	60.5	64.8	58.5
1.14	0.69	1.12	0.86	0.91	1.04	1.36	1.03	1.18	1.05	0.84	1.56	1.08	0.97	0.90	0.88	1.00
14.8	8.8	14.9	11.7	13.1	13.6	20.7	15.7	15.6	14.1	12.2	21.2	14.1	12.7	11.7	11.4	12.6
0.11	0.16	0.18	0.01	0.44	0.33	0.32	0.12	0.09	0.56	0.26	0.18	0.52	0.22	0.25	0.21	0.28
1.4	2.0	2.3	0.2	6.4	4.3	4.8	1.8	1.3	7.5	3.8	2.4	6.8	2.9	3.2	2.7	3.5
58	46	48	46	48	51	59	55	52	55	60	50	52	56	56	56	45

R. T.

FOLDOUT FRAME

Table III.

	AVERAGE VALUES			BETWEEN GROUP COMPARISONS * (P=0.05)		
	Pre-bedrest	Bedrest	Post-bedrest	Pre-bedrest vs. Bedrest	Pre-bedrest vs. Post-bedrest	Bedrest, vs. Post-bedrest
Total Time in Bed	8.04(0.01)	8.04	8.03	N.S.	N.S.	N.S.
Total Sleep Time	7.77(0.08)	7.43	7.55	N.S.	N.S.	N.S.
Total Sleep Percent	96.60(0.80)	92.40	94.00	N.S.	N.S.	N.S.
Total Awake Time	0.27(0.07)	0.61	0.48	N.S.	N.S.	N.S.
1st 3rd	0.07(0.04)	0.35	0.11	N.S.	N.S.	N.S.
2nd 3rd	0.07(0.03)	0.07	0.14	N.S.	N.S.	N.S.
3rd 3rd	0.14(0.06)	0.18	0.24	N.S.	N.S.	N.S.
Sleep Latency	0.13(0.06)	0.44	0.17	N.S.	N.S.	N.S.
REM Latency	1.00(0.14)	0.82	1.16	N.S.	N.S.	0.05
Number of Awakenings	16.30(4.90)	18.70	25.20	N.S.	0.05	0.05
1st 3rd	1.70(1.50)	1.70	1.20	N.S.	N.S.	N.S.
2nd 3rd	6.30(1.10)	6.00	7.20	N.S.	N.S.	N.S.
3rd 3rd	8.30(3.50)	11.00	16.80	N.S.	0.05	0.05
Number of REM Periods	16.70(5.50)	19.90	24.20	N.S.	0.05	N.S.
1st 3rd	2.30(1.10)	3.00	3.30	N.S.	N.S.	N.S.
2nd 3rd	5.70(1.50)	6.80	7.00	N.S.	N.S.	N.S.
3rd 3rd	8.70(3.80)	10.10	13.80	N.S.	N.S.	N.S.
Stage I Time	1.11(0.31)	1.03	1.47	N.S.	N.S.	0.05
% Stage I	14.30(4.10)	13.90	19.60	N.S.	N.S.	0.05
Stage REM Time	1.67(0.13)	1.88	1.83	N.S.	N.S.	N.S.
1st 3rd	0.34(0.10)	0.31	0.28	N.S.	N.S.	N.S.
2nd 3rd	0.57(0.16)	0.67	0.53	N.S.	N.S.	N.S.
3rd 3rd	0.77(0.15)	0.89	1.03	N.S.	0.05	N.S.
% Stage REM	21.60(1.70)	25.30	24.20	N.S.	N.S.	N.S.
Stage 2 Time	3.98(0.42)	3.39	3.22	0.05	0.05	N.S.
% Stage 2	51.20(5.10)	45.50	42.60	N.S.	0.05	N.S.
Stage 3 Time	0.75(0.11)	0.85	0.78	N.S.	N.S.	N.S.
% Stage 3	9.70(1.40)	11.60	10.30	N.S.	N.S.	N.S.
Stage 4 Time	0.25(0.07)	0.28	0.25	N.S.	N.S.	N.S.
% Stage 4	3.20(0.90)	3.80	3.30	N.S.	N.S.	N.S.
Transitions / Hr.	47.00(7.00)	44.00	47.30	N.S.	N.S.	N.S.

Subject: J.H.

* Mann-Whitney U Test

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Table IV.

	AVERAGE VALUES			BETWEEN GROUP COMPARISONS * (P = 0.05)		
	Pre-bedrest	Bedrest	Post-bedrest	Pre-bedrest vs. Bedrest	Pre-bedrest vs. Post-bedrest	Bedrest, vs. Post-bedrest
Total Time in Bed	8.05(0.01)	8.06	8.04	N.S.	N.S.	N.S.
Total Sleep Time	7.67(0.02)	7.34	7.68	N.S.	N.S.	N.S.
Total Sleep Percent	95.40(0.30)	91.00	95.50	N.S.	N.S.	N.S.
Total Awake Time	0.37(0.03)	0.73	0.37	N.S.	N.S.	N.S.
1st 3rd	0.13(0.05)	0.59	0.15	N.S.	N.S.	0.05
2nd 3rd	0.06(0.07)	0.08	0.10	N.S.	N.S.	N.S.
3rd 3rd	0.18(0.07)	0.07	0.12	0.02	N.S.	0.05
Sleep Latency	0.16(0.09)	0.62	0.17	N.S.	N.S.	N.S.
REM Latency	1.86(0.77)	1.07	1.92	0.05	N.S.	0.02
Number of Awakenings	17.30(3.00)	9.60	11.80	N.S.	N.S.	N.S.
1st 3rd	1.70(2.10)	1.08	1.00	N.S.	N.S.	N.S.
2nd 3rd	5.30(4.90)	3.10	3.30	N.S.	N.S.	N.S.
3rd 3rd	10.30(3.50)	5.40	7.50	0.02	N.S.	0.05
Number of REM Periods	8.00(1.00)	10.80	8.70	N.S.	N.S.	N.S.
1st 3rd	1.70(0.60)	2.80	1.50	N.S.	N.S.	N.S.
2nd 3rd	3.00(1.00)	3.50	2.50	N.S.	N.S.	N.S.
3rd 3rd	3.30(1.50)	4.40	4.70	N.S.	N.S.	N.S.
Stage I Time	0.48(0.03)	0.40	0.50	N.S.	N.S.	0.02
% Stage I	6.20(0.40)	5.50	6.50	N.S.	N.S.	N.S.
Stage REM Time	1.55(0.40)	1.78	1.45	N.S.	N.S.	0.02
1st 3rd	0.09(0.01)	0.17	0.15	N.S.	N.S.	N.S.
2nd 3rd	0.74(0.42)	0.61	0.44	N.S.	N.S.	N.S.
3rd 3rd	0.72(0.03)	1.00	0.86	N.S.	0.05	N.S.
% Stage REM	20.20(5.20)	24.00	18.90	N.S.	N.S.	0.02
Stage 2 Time	4.56(0.50)	3.9[illegible]	4.39	N.S.	N.S.	N.S.
% Stage 2	59.40(6.40)	53.30	57.10	N.S.	N.S.	N.S.
Stage 3 Time	0.91(0.26)	1.01	1.07	N.S.	N.S.	N.S.
% Stage 3	11.80(3.30)	13.90	14.00	N.S.	N.S.	N.S.
Stage 4 Time	0.18(0.21)	0.22	0.28	N.S.	N.S.	N.S.
% Stage 4	2.40(2.80)	3.10	3.60	N.S.	N.S.	N.S.
Transitions / Hr.	48.00(8.00)	51.20	52.50	N.S.	N.S.	N.S.

Subject: R.T.

* Mann-Whitney U Test

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Table V.

Subject: J.H.

	AVERAGE VALUES				BETWEEN GROUP COMPARISONS * ($P \leq 0.05$)		
	Pre-bedrest	Bedrest, First Half	Bedrest, Second Half	Post-bedrest	Pre-bedrest vs. Bedrest, First Half	Pre-bedrest vs. Bedrest, Second Half	Pre-bedrest vs. Post-bedrest
Total Sleep Time	7.77	7.72	7.23	7.55	N.S.	0.02	N.S.
Sleep Latency	0.13	0.21	0.59	0.17	N.S.	N.S.	N.S.
REM Latency	1.00	1.11	0.62	1.16	N.S.	N.S.	N.S.
No. of Awakenings	16.30	17.00	19.90	25.20	N.S.	N.S.	0.05
No. of REM Periods	16.70	18.40	21.00	24.20	N.S.	N.S.	0.05
% Stage I	14.30	12.60	14.80	19.60	N.S.	N.S.	N.S.
% REM	21.60	25.70	25.00	24.20	0.05	N.S.	N.S.
% Stage 2	51.20	47.80	43.90	42.60	N.S.	0.05	0.05
% Stage 3	9.70	10.10	12.60	10.30	N.S.	0.05	N.S.
% Stage 4	3.20	3.90	3.70	3.30	N.S.	N.S.	N.S.

* Mann-Whitney U Test

Table VI.

Subject: R.T.

	AVERAGE VALUES				BETWEEN GROUP COMPARISONS * (P≤ 0.05)		
	Pre-bedrest.	Bedrest, First Half	Bedrest, Second Half	Post-bedrest	Pre-bedrest vs. Bedrest, First Half.	Pre-bedrest vs. Bedrest, Second Half	Pre-bedrest vs. Post-bedrest
Total Sleep Time	7.67	7.66	7.10	7.68	N.S.	0.01	N.S.
Sleep Latency	0.16	0.25	0.89	0.17	N.S.	0.01	N.S.
REM Latency	1.86	1.38	0.85	1.92	N.S.	0.05	N.S.
No. of Awakenings	17.30	9.60	9.60	11.80	N.S.	N.S.	N.S.
No. of REM Periods	8.00	12.00	9.90	8.70	N.S.	N.S.	N.S.
% Stage I	6.20	5.20	5.80	6.50	0.05	N.S.	N.S.
% REM	20.20	24.80	23.80	18.90	N.S.	N.S.	N.S.
% Stage 2	59.40	56.30	51.20	57.10	N.S.	0.05	N.S.
% Stage 3	11.80	12.40	15.00	14.00	N.S.	N.S.	N.S.
% Stage 4	2.40	1.30	4.30	3.60	N.S.	N.S.	N.S.

* Mann-Whitney U Test

Table VII.

COMPARISON OF SKYLAB, BEDREST, AND S.M.E.A.T. RESULTS

SLEEP CHARACTERISTICS	INCIDENCE OF ALTERED SLEEP CHARACTERISTICS (Percentage of Group Membership)			% CORRELATION $\frac{n_1 \times n_2 \cdots n_x}{10^{2x-2}}$		
	SKYLAB n=3	BEDREST n=2	S.M.E.A.T. n=2	OVERALL	SKYLAB & BEDREST	SKYLAB & S.M.E.A.T.
Increased During Exposure						
Sleep Latency	33	100	50	17	33	17
Stage 2	0	0	50	0	0	0
Stage 3	100	100	50	50	100	50
Stage 4	33	50	50	8	17	[illegible]
Stage REM	C	100	0	0	0	0
Decreased During Exposure						
Sleep Latency	33	0	0	0	0	0
Sleep Time	67	100	50	34	67	34
Stage 1	67	50	100	34	34	67
Stage 2	33	100	0	0	33	0
Stage 3	0	0	50	0	0	0
Stage 4	33	0	50	0	0	17
Stage REM	67	0	50	0	0	34
REM Latency	0	100	0	0	[illegible]	0
Increased Post-Exposure						
Sleep Time	33	0	0	0	0	0
Stage 1	33	50	0	0	17	0
Stage 2	33	0	50	0	0	17
Stage REM (>R+3)	100	50	100	50	50	100
Decreased Post-Exposure						
Sleep Latency	33	0	C	0	0	0
Stage 1	0	0	100	0	0	0
Stage 2	0	50	0	0	C	0
Stage 3	100	0	50	0	0	50
Stage 4	100	0	50	0	0	0
Stage REM (<R+3)	33	0	Q	0	0	0
REM Latency (>R+3)	100	0	0	0	0	0